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Lasagna™ Public-Private Partnership

RTDF

Remediation Technologies Development Forum

RTDF Action Teams

Lasagna™ Partnership

Bioremediation Consortium

Permeable Barriers Action Team

IINERT Soil-Metals Action Team

Sediments Remediation Action Team

What is the Lasagna™ Public-Private Partnership?

In early 1994, the U.S. Environmental Protection Agency (EPA) signed a Cooperative Research and Development Agreement (CRADA) with a private Research Consortium—consisting of Monsanto, DuPont, and General Electric—to jointly develop an integrated, *in-situ* remedial technology referred to as the Lasagna™ process. In 1995, with significant funding from the Department of Energy (DOE), a field experiment was initiated at the DOE Paducah Gaseous Diffusion Plant (PGDP) in Kentucky, to test the Lasagna™ process. This collaborative effort between the federal government and industry evolved as a separate Action Team of the Remediation Technologies Development Forum (RTDF). The RTDF was established in 1992 by EPA after industry representatives met with the Administrator to identify ways of working together to solve complex hazardous waste site contamination problems.

What is the Problem of Concern?

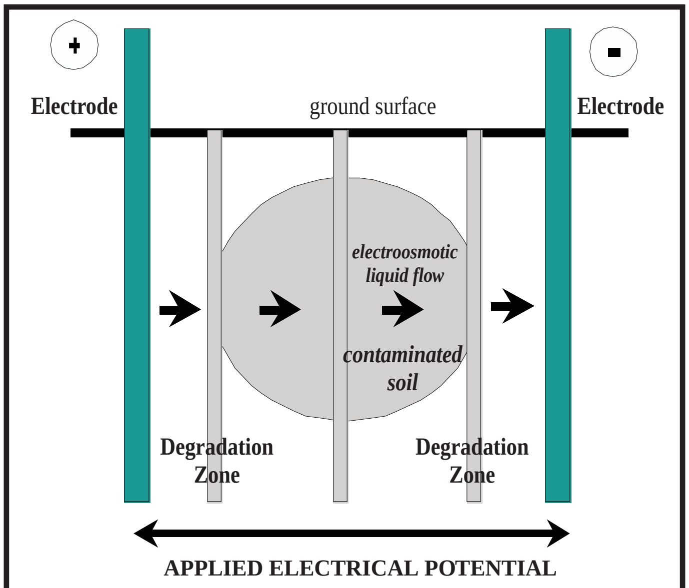
Contamination in low permeability soils poses a significant technical challenge to *in-situ* remediation efforts. Accessibility of the contaminants and delivery of treatment reagents have posed problems, rendering traditional tech-nologies—such as vapor extraction and pump-and-treat—rather ineffective when applied to low-permeability soils present at many contaminated sites.

What is the Lasagna™ Process?

The Lasagna™ process, so named because of its treatment layers, combines electroosmosis with treatment zones that are installed directly in the contaminated soils to form an integrated *in-situ* remedial process. Electroosmosis, used for years by civil engineers, is well known for its effectiveness in moving water uniformly through low-permeability soils at very low power consumption. Conceptually, the Lasagna™ process would be used to treat organic and inorganic contaminants, as well as mixed wastes.

The Lasagna™ process is designed to treat soil and groundwater contaminants completely *in situ*, without the use of injection or extraction wells. If successful, it could replace the more conventional methods for containing and treating contaminants in low-permeability soils. The schematic diagrams on the next page depict both the horizontal and vertical configurations of the Lasagna™ process.

Vertical Configuration of the Lasagna™ Process



Note: Electroosmotic flow is reversed upon switching electrical polarity.

As illustrated in the diagrams, the outer layers consist of either positively or negatively charged electrodes. The electric field created by the electrodes moves contaminants in soil pore fluids into or through the treatment layers.

In-situ decontamination using the Lasagna™ process can occur by:

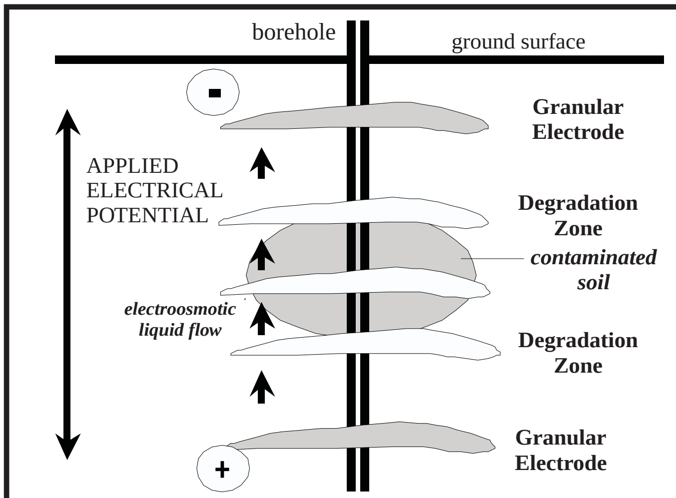
- **Creating zones** in close proximity to one another throughout the contaminated soil region, and converting them into sorption/degradation zones by introducing appropriate materials (e.g., sorbents, catalytic agents, microbes, oxidants, buffers, etc.). Hydraulic fracturing and related technologies may provide an effective and low-cost means for creating such zones horizontally in the subsurface soil. The degradation zones can also be emplaced vertically as depicted in the schematic above. In the vertical configuration, sheet piling, trenching, and slurry walls can be used to create the treatment zones.

- **Utilizing electroosmosis as a liquid pump** for flushing contaminants from the soil into the treatment zones for degradation. Locating these zones close to one another minimizes the time it takes for the liquid to be moved by electroosmosis from one zone to the next. In the horizontal configuration, hydrofracturing is used to place graphite or other granular, electrically conductive materials in zones above and below the contaminated soil area to form the electrodes in place. For highly non-polar contaminants, surfactants can be introduced into the water or incorporated into the treatment zones to solubilize the organics.

- **Switching electrical polarity to reverse liquid flow,** which may increase the efficiency of contaminant removal from the soil, as well as allow multiple passes of the contaminants through the treatment zones for complete sorption/degradation. Polarity reversal also minimizes complications associated with long-term applications of one-directional electroosmotic processes. Optionally, the cathode effluent (high pH) can be recycled back to the anode side (low pH), which provides a convenient means for pH neutralization and water management.

The orientation of the electrodes and the treatment zones depends on the site/contaminant characteristics. In general, the vertical configuration is probably applicable to more shallow contamination (i.e., within 50 feet of the ground surface), whereas the horizontal configuration, using hydraulic fracturing or related methods, is capable of treating much deeper contamination.

Horizontal Configuration of the Lasagna™ Process



Note: Electroosmotic flow is reversed upon switching electrical polarity.

What is the Mission of the Partnership?

The mission of the Lasagna™ Partnership—which includes private industry, DOE, and EPA—is to pool expertise and resources to advance the development of the Lasagna™ process to remediate organic and inorganic contaminants in dense soils. The overall goal of the Partnership is to sufficiently develop the Lasagna™ technology so that it can be utilized for site remediation. The initial focus of the study was development of the vertical process for remediation of chlorinated solvents. The Partnership members collectively performed research to integrate a viable treatment process via a combination of electrokinetics and treatment zones; destruction via bioremediation, catalysis, or other technique; and adsorption. Laboratory and field tests, process simulation, and cost analyses were performed and modifications were made, which ultimately led to the field demonstration of the vertical configuration of the Lasagna™ process (Phase I-Vertical test) at Paducah, KY.

What Has Been Accomplished?

The Phase I-Vertical field test, which operated for 120 days at the DOE PGDP, was completed in May 1995. One of the key objectives of this study was to successfully demonstrate the coupling of electroosmotic flushing of trichloroethylene (TCE) from the clay soil with its removal from the pore water by *in-situ* adsorption. The test site measured 15 feet wide by 10 feet across and 15 feet deep. Steel panels were used as electrodes and the treatment zones consisted of wickdrains containing granular activated carbon. In Phase I-Vertical, carbon was used in the treatment zones to perform mass-balance calculations. Sampling and analysis of the carbon at the end of the study accounted for a substantial amount of the TCE. Monitoring TCE levels in the air during the test showed that only 4% of the total TCE was lost through evaporation. Scale-up from laboratory units was successfully achieved with respect to electrical parameters and electroosmotic flow. Soil samples taken throughout the site, before and after the test, indicate a 98% removal of TCE from a tight clay soil (i.e., hydraulic conductivity $<10^{-7}$ cm/sec), with some samples showing greater than 99% removal. **TCE soil levels were reduced from the 100 to 500 ppm range to an average concentration of 1 ppm.**

The University of Cincinnati, through a Cooperative Agreement funded by EPA, is conducting laboratory and field research on hydrofracturing and biodegradation to develop the horizontal configuration. This work,which has been performed in clean soils, has focused on developing durable electrical and fluid connections to the horizontal (hydraulic fracture) electrodes and treatment zones and solving the problem of gas generation in the electrodes. Six different horizontal test units have been installed; the survival of a methanotropic microorganism in a treatment zone is currently being examined while the electrodes above and below are energized to move water by electroosmotic processes. The treatment zone is composed of granular activated carbon, which was seeded with microorganisms and nutrients before it was installed via hydrofracturing. The microorganism was isolated from a group of organisms and was selected for its ability to degrade TCE. Preliminary tests have been conducted at sites in Ohio and Nebraska to determine their suitability for a field test of the horizontal Lasagna™ configuration.

What Are the Partners' Roles?

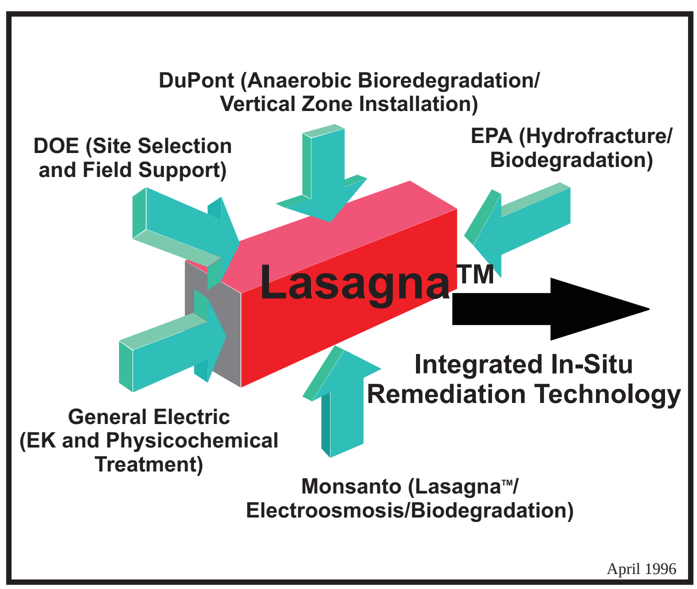
Each partner brings particular knowledge and expertise, as well as contributes the resources necessary to complete the Partnership's research and development mission. The three companies share proprietary technologies and their collective understanding of electrokinetics, catalytic dechlorination, bioremediation, process simulation, and cost analysis to support development and evaluation of the Lasagna™ process. DOE brings to the project knowledge of electrokinetics and bioremediation and provides funding and analytical and field support for the studies at the PGDP.

EPA's National Risk Management Research Laboratory (EPA/NRMRL) in Cincinnati is leading the investigation of emplacement and operation of the horizontal configuration of the Lasagna™ process. In conjunction with the University of Cincinnati, EPA/NRMRL is using hydrofracturing to create electrodes and treatment zones in subsurface soils and is selecting microorganisms that can degrade contaminants and survive electroosmosis. EPA/NRMRL is also investigating the basic geochemistry of the Lasagna™ process to provide a sound basis for optimization. The Partnership is facilitated by Clean Sites under a cooperative agreement with EPA's Technology Innovation Office and by The Scientific Consulting Group under a contract with EPA's Office of Research and Development.

What Activities Are Planned?

The success of the Phase I-Vertical field experiment has led to plans for conducting additional field studies incorporating reactive treatment zones, such as iron filings, to destroy TCE *in situ*. The Phase II-Vertical field experiment, which will

Lasagna™ Partnership Members



also be conducted at the DOE PGDP, is expected to consist of two stages. In the first stage (Phase IIa-Vertical), the Lasagna™ process will be used to treat approximately 20 times more soil than was treated in Phase I-Vertical. This study will help resolve any scale-up questions, substantiate technology cost estimates, and evaluate the performance of zero-valent iron in the treatment zones. If the test is successful, the PGDP Environmental Restoration Program is planning to use the technology to remediate the entire Solid Waste Management Unit. Direct treatment costs for a typical one-acre site are estimated at $50/yd^3 of soil and the remediation could occur over a period of 3 years. In the spring of 1996, the Partnership's Phase IIa-Vertical Lasagna™ demonstration was selected for inclusion in the federal government's Rapid Commercialization Initiative (RCI). Participation of California EPA, Southeastern States Energy Board, the Western Governors Association, and various state environmental agencies in RCI will help facilitate regulatory acceptance and the widespread use of the Lasagna™ technology. Results from Phase IIa-Vertical and Phase IIb-Vertical field studies will be used to produce verified cost and performance data for the Lasagna™ process, which will also greatly increase its acceptance and use. Various treatment processes are currently being investigated in the laboratory to address other types of contaminants, such as DNAPLs, heavy metals, and mixed wastes.

The work on gas generation and electrical/fluid connections for horizontal emplacements in clean soil was completed during the summer of 1996. Phase I-Horizontal field tests in TCE-contaminated soils will be conducted in the fall of 1996 at sites in Ohio and Nebraska, where preliminary testing has already been conducted.

Who are the Members of the Lasagna™ Partnership?

DuPont
General Electric
Monsanto

U.S. Environmental Protection Agency
U.S. Department of Energy

Additional organizations involved in the projects include Lockheed Martin Energy Systems, Nilex, API, CDM Federal, University of Cincinnati, the State of Kentucky, and the U.S. Air Force.

To request other RTDF factsheets, please write/fax to:

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RTDF
Remediation Technologies Development Forum

Would You Like More Information?

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